Institute *of* **Physics**

History of Physics Group

Newsletter

2003

No. 16

Contents

Editorial

Welcome to issue 16 of the Newsletter.

2002 was a year of meetings around the country: we have photos from the Oxford walk, and accounts of the Dirac meeting in Bristol, and the Airy meeting in Newcastle, as well as papers from the Newcastle meeting.

This issue also contains some correspondence sent in response to earlier newsletters. We have a letter from Bragg's grandson, alongside an article about the Braggs in Leeds. We also have a reply to the feature we ran on the Bath Heritage walk last year, from the project leader.

The End Papers section includes a review of The Road to Stockholm *(a book about the history of Nobel Prizes in science) and some items to commemorate the tercentenary of Hooke's death.*

And lastly, apologies to those of you who were sent last year's newsletter twice – a mix up with HQ, I'm afraid. We'll endeavour to send you this one only once!

Date for your diary:
Saturday 11th Oct
October meeting, IoP HQ

Lucy Gibson

History of Physics Group Committee:

Chairman	**Professor Ian Butterworth** The Blackett Laboratory, Imperial College Prince Consort Road, LONDON SW7 2BW i.butterworth@ic.ac.uk
Hon. Secretary & Treasurer	**Dr. Peter Ford** pyspjf@bath.ac.uk
Newsletter Editor	**Mrs. Lucy Gibson** 56 Priory Avenue, LONDON E17 7QP lucy.gibson@bbc.co.uk
Web Pages Editor	**Dr. C. Hempstead** colin.hempstead@ntlworld.com
Also:	**Mr. C. N. Brown**
	Prof. R. Chivers
	Ms. O. Davies
	Ms. S. Duncan
	Dr. C. Green
	Dr. C. Ray
	Dr. P. Rowlands
	Prof. D. Weaire

Committee movements

There have been several changes in the committee this year, with a new Honorary Secretary and Web Pages Editor. We welcome Colin Hempstead, Dennis Weaire and Peter Ford, and wish Sophie Duncan and Mike Thurlow all the best.

Mike Thurlow

Mike Thurlow has been Web Pages Editor for the group since 1998. He has patiently seen through the changes in technology which the IoP have brought in for the site in general, and actively thought up new ways in which the group could make use of the web, particularly suggesting that as the group is so geographically diverse – with members often having difficulty attending meetings – the web should be an ideal resource for us. There is therefore huge potential for us here, and Mike has left us in a good position to start to harness that. He is succeeded in his post by Colin Hempstead.

Sophie Duncan

by Neil Brown

Sophie joined the committee in 1998 and was Honorary Secretary for three years, under the chairmanship first of John Roche and then Ian Butterworth. The role of Honorary Secretary of almost any organisation can be frustrating. There are periods when almost nothing seems to be happening separated by bouts of hectic activity, usually at the most inconvenient of times, to ensure that meetings take place as planned. Sophie brought her persistence, tact, and persuasiveness to the job, and tackled it with her usual conscientiousness.

At the time she joined the committee, Sophie was working at the Science Museum in London. In 2000, she left to take up a post at Science Year, an exciting initiative to promote science particularly to young people, thus combining two of her passions. Having successfully completed that project, she accepted a part-time job at the BBC, which allowed her also to begin a part-time theology course. No-one who knows Sophie doubts that both will receive much more than the part-time commitment they are supposed to require. She is succeeded in her post by Peter Ford.

Future Meeting arranged by this Group

October Meeting

Plans are shaping up for the October meeting:

DATE: Saturday, 11th October 2003.

TIME: 13.00 hrs (timings may change)

PLACE: Institute of Physics, 76 Portland Place, London, W1B 1NT, UK

Isobel Falconer – "Formulating a theory: J J Thomson and Ernest Rutherford's collaboration on x-ray ionisation"

Colin Hempstead – "Chance and Choice in the History of Physics"

Denis Weaire – "Thomson and Fitzgerald - Natural Philosophers"

For further information, contact colin.hempstead@ntlworld.com
(Dr Colin A Hempstead, 2 Uplands Road, Darlington DL3 7SZ)

The Group's Website:
www.iop.org/IOP/Groups/HP/

Chairman’s Report

Given to the Group at the AGM, Saturday 19th October 2002

Since our Honorary Secretary, Sophie Duncan is unable to join us today, I will roll together her and my report of what has happened since our last AGM in December last year.

And a sensible starting point is the production of the 15th number of our Newsletter, again very successfully by its editor, Lucy Gibson. I am sure we all very much enjoy it, and indeed we received a congratulatory letter from a Dr. Rahakrishna all the way from Puttar on the West Coat of India, where he lectures on physics at St. Philomena College there.

The Newsletter included the talks at the Nobel Century Meeting at the Science Museum in December given by Sir Joseph Rotblat, Professor Widmalm and Peter Rowlands. It also included the talk on UFOs and Aliens given by Dr Jacqeline Mitton at our earlier meeting on Space. Feature articles were also included by Kate Crennel, Malcolm Cooper and again Peter Rowlands. A bumper volume!

An effective innovation, suggested and organized by Olivia Davies was the Scientific Walk through Oxford. About 35 people attended, including some who had never before come to any of our events. It was an unbelievably windy day, but despite that was a most enjoyable event. Olivia guided us and had put in an enormous effort in finding the details in the work of Wren, Boyle, Hooke, Halley and the places with which they were particularly associated – this included a visit to the Wren-built Museum of the History of Science. We finished with a lecture at the Clarendon when we were joined by some more locals raising the audience to 55.

On 9th April, the History of Physics Group, together with the High Energy Physics Group, organised a half-day meeting within the Annual IOP Congress at Brighton to mark the Centenary of the birth of Dirac. There were four speakers: Helge Kragh on ‘The Life and Times of Dirac’, Sir Roger Penrose on ‘Dirac’s Influence’, Neil Turok on ‘Antimatter and Cosmology’ and Sir Chris Llewellyn Smith on ‘Particle Physics and Dirac’. It was without doubt the most successful event at the Congress, with a large lecture room so filled that not everyone who wanted to listen able to get in.

As regards our Committee, Colin Hempstead joined us and plunged in straight away to organize this meeting on Airy here in Newcastle.

Sophie Duncan has come to the end of her term as Honorary Secretary. She unfortunately cannot come to the meeting today so I can't thank her properly – just sending an email is not enough! I am personally very grateful that she was willing to stay on an extra year after I know pressure of work made it very difficult. We can all be very grateful for the hard work she has done for the Group – and I hope we will still have her helping us.

Ian Butterworth, Chairman

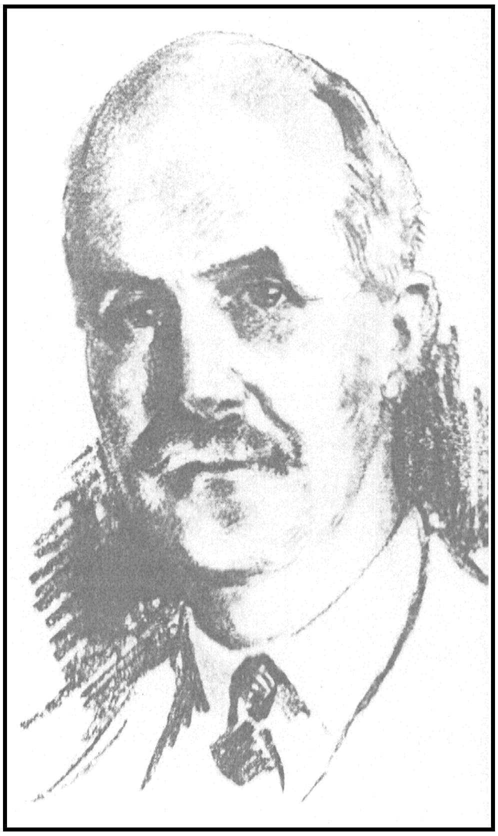
The Group's Website:
www.iop.org/IOP/Groups/HP/

Disclaimer

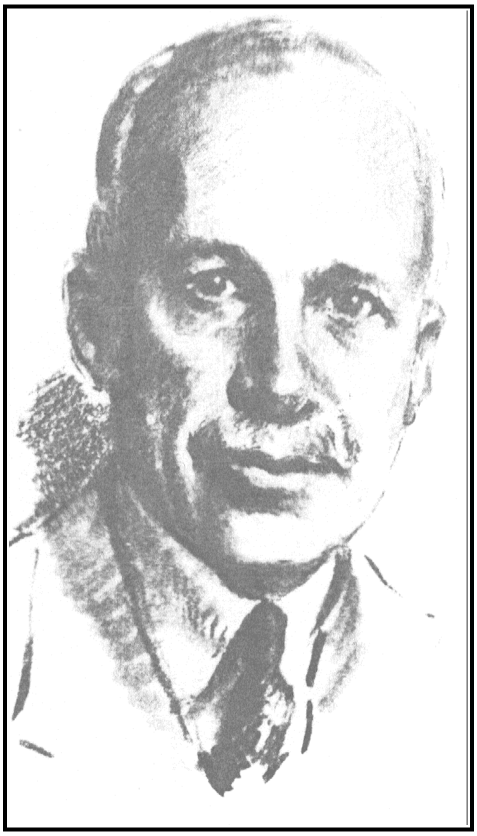
The History of Physics Group Newsletter expresses the views of the Editor or the named contributors, and not necessarily those of the Group nor of the Institute of Physics as a whole. Whilst every effort is made to ensure accuracy, information must be checked before use is made of it which could involve financial or other loss. The Editor would like to be told of any errors as soon as they are noted, please.

The two Braggs, Leeds in 1912, and the birth of Structural Crystallography*

John Robertson
University of Leeds



Sir William Henry Bragg
1862 - 1942



Sir William Lawrence Bragg
1890 - 1971

It was Max von Laue, in München, who had the supreme intuition (in mid-1912) that X-rays might be diffracted by crystals. He was right, and won the Nobel Prize for it. He also set out the famous Laue equations; but then, he left the matter. The physics of the phenomenon had, of course, been very neatly tied up. It was the Braggs, at Leeds, a few months later,

* This article first appeared in the Newsletter of the British Crystallography Association, 1997, and is reproduced here with the kind permission of the Editor.

who realised that X-ray diffraction was a key to a knowledge of the internal structure of crystals.

It is common knowledge that sodium chloride was the first crystal structure to be determined, and that its solution, along with the other alkali halides, was greatly assisted by the ideas of Pope and Barlow. But how, exactly, did the Bragg Equation get invented? Eighty four years after the event none of the details of that crucial advance in crystallography are as clear as we would like, but it seems that what happened was something like this:

Both the Braggs - father (WH) and son (WL) - were fascinated by the question, Were X-rays really waves, not particles? WH, who had been in Leeds already for three years (as Cavendish Professor of Physics) had the service of an excellent workshop; X-rays were available in his laboratory, so the experiments of Laue, Friedrich and Knipping were easily repeated. Meanwhile, WL, who had newly graduated in Maths and Physics at Cambridge, was a research student in Cambridge, under J. J. Thompson; but he joined his father whenever possible, in the vacations. On holiday, in the summer of 1912, they began discussing Laue's discovery; soon after, they started their own experiments. Back in Cambridge after the vacation, WL studied Laue's photographs further ... and it was there that he then had his brain wave.

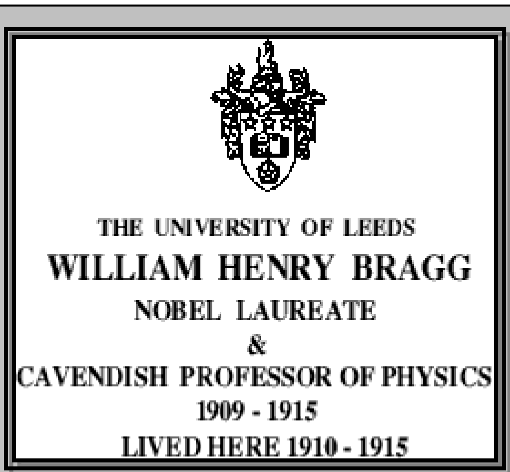
Young (22), independent, full of ideas, and with his University Physics lectures still fresh in his mind, WL remembered C.T.R. Wilson's lecture course on optics, particularly CTR's treatment of optical diffraction by a grating. CTR had shown that a "form-less pulse" (today, we would say, some white radiation) is split up by a grating into its component wavelengths, each emerging in its own geometrically determined direction; for a line grating the directions could be specified by equations of the type, $n\lambda = a\sin(\theta)$.

With these ideas in his mind he also recalled the well-known Huygens construction for the reflection of waves by the points of a plane surface. As soon as reflection was thought of, WL found that it explained the Laue pictures at once. (He especially liked its explanation of the elliptical shape of the Laue spots.) He then checked his idea experimentally with a piece of mica (it was CTR's suggestion to use something like that) since mica must have well-marked planes of atoms, because it cleaves so well. Sure enough, the mica behaved just like a mirror. WL took his photographic plate, still wet from the fixer solution, down to JJ's room to show him, and JJ was quite excited by it. So, with reflection now as the basic concept, the Bragg equation followed almost automatically:

$$n\lambda = 2d\sin(\theta)$$

(Of this Bragg Law, WL wrote later that it was an easily earned honour to have it named after him because, after all, it was "merely the familiar relation giving the colours reflected by thin films".) Once having such a simple key to the interpretation of diffraction, WL lost no time in showing how it could be applied. It was on November 11th that year (still 1912) that he read a paper to the Cambridge Philosophical Society on how the structure of rock salt could be deduced.

As for WH, in Leeds, he enthusiastically embraced the wave theory as a result of WL's insight. The ionisation spectrometer constructed under his direction (in that excellent workshop) was explicitly based on the reflection principle. With that fine instrument as their source of experimental data (far better than Laue photos) WH and WL jointly solved the diamond structure, and WL went on to publish the now-classic series of papers on the alkali halides, ZnS, CaF_2, Calcite, and Pyrite. That was 1912-14. Structural Crystallography had begun.



This inscription is to be found on a plaque on the wall of "Rosehurst", the University of Leeds house in which the Braggs lived during their time in Leeds. It is still used for accommodation for visitors to the University. There are three other Bragg commemorative plaques on the Leeds campus.

Letter from Bragg’s grandson

In an earlier newsletter, we featured an article by Malcolm Cooper about W H Bragg’s early life. We subsequently received a letter from Stephen Bragg, his grandson. He has kindly agreed for it to be reproduced here:

I commissioned the plaque commemorating my grandfather’s birth at Stoneraise Place from Mr Will Carter, who made it from Westmorland green slate. All WHB’s grandchildren contributed to the cost. It was erected in 1990 by Mr and Mrs Bainbridge who then owned the house. I am afraid I can throw no light on the drawings, though Mr Bainbridge did tell me that the brothers’ signatures had been in one of the barns before it was whitewashed in the late 1960s.

Malcolm Cooper might like to check with Tully House Museum the description of Figure 2 as a “portrait painted in 1934”. I have one of a similar set of sketches done by William Rothenstein in 1921 and this is certainly a drawing and not a painting. We supplied a copy to the University of Leeds who have I believe hung it in Rosemount, the house occupied by the family when my grandfather was professor there and now used for university entertaining.

The Bragg archives are held by the Royal Institution, but I would be happy to answer any queries that I can,

Stephen Bragg

Dear Miss
A colleague, passed to me a copy of the History of Physics ... Physics. It contained a ... Cooper referring to the ... grandfather, William Henry ... would be kind enough to pass ... comments on to the author.
I commissioned the plaque ... my grandfather's birth at Stoneraise Place ... Mr Will Carter, who made it from ... green slate. All WHB's grandchildren ... to the cost. It was erected in 1990 by Mr and Mrs Bainbridge who then owned the house.

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The Bragg archives are held by the Royal Institution, but I would be happy to answer any queries that I can.
Yours sincerely
Stephen Bragg
STEPHEN BRAGG

The Bath Heritage Walk: a reply

In the last Newsletter, we ran an article comparing the Bath Scientific Heritage Trail with the Oxford Science Walk. Colin Axon, Project Leader of the Bath trail, contacted us to reply to the article:

Thank you very much for reviewing the Bath Heritage Trail in the recent Newsletter. We welcome feedback, as we are planning a second edition, and other similar projects. It is in this positive framework that the many volunteers who are closely involved in the project would welcome the chance to clarify a couple of points and respond to some of the comments and criticism (implied and direct) made by [the author].

For clarification, we wish to make it clear that neither the Trail project nor the West of England Branch of the British Association for the Advancement of Science have any connection with the Landmark Trust. The second point of clarification is that the Trail is a British Association (BA) project. The Bath Royal Literary and Scientific Institution (BRLSI) assisted us with some of the information gathering. Also in the article's introduction, the BA was incorrectly referred to as the "British Association for the Understanding of Science".

Sadly, [the author] was misinformed by the BRLSI – the poster/guide is not free (except to schools and some other organisations). COPUS and the IOP were only part funders, but we have indeed given a great many copies away free. Every school with a Bath postcode has been given many unfolded copies, and local clubs and societies have been given enough copies for their members. The remainder are being sold for 75p each. The vendors are mostly the local museums, independent bookshops, and the tourist office – they keep 25p. The remaining 50p is for reclaiming the shortfall in production costs, and hopefully building some funds towards a second edition.

To address [the author]'s concerns regarding our choice of style and layout. [She] correctly identified that the poster/guide does not have a compass point. This was a deliberate decision: in line with all maps, it is convention that North is at the top. Another decision we came to after considerable consultation was not to give a set path to follow. As [the author] pointed out herself, there are many points at which one might start depending upon mode or direction of travel. We felt that it was better to let people make their own decisions, rather than suggest a tortuous path around the city. In a linear booklet style (such as Oxford), this approach makes some sense, but for a publication which displays the whole area on one piece of paper, we could find no reason to clutter the appearance. And as for there being no detailed directions – a map is exactly that! A picture (or diagram) is worth a thousand words.

Our website is not what we would like it to be – it is basic. However, we all have day jobs and simply have not had the time to improve it further, and we welcome all offers of assistance! Whilst we cannot speak for Oxford, we suspect that they may be in a similar situation.

From her description, we assume that it was William Smith's office in Trim Street that [the author] was unable to find. It is not the red blobs which mark the exact location, but the coloured drawings of the houses. Whilst [the author] is the first person to have brought this problem to our attention, we will look to see if we can find a way of improving the clarity of this particular site on the map. We can assure her that Smith's office is still standing!

Bath has not been ruined *for* motorists, but has been ruined *by* motorists. A number of recent road developments by the local Council have improved the air quality and the pedestrian experience considerably. We urge visitors to come by public transport or use one of the many Park and Ride sites and enjoy a pleasant and safe city centre. Quite deliberately we chose to spread the sites further than the "Tourist Square Mile" in Bath as there is so much more to this beautiful city. We wished to appeal to residents too, by showing some of the interesting and important things that have happened in their neighbourhood. And we shamelessly decided to plug as many of the local science and engineering related museums and attractions as possible, as many of them are off the beaten track. This approach has been warmly welcomed by many people, and hope that this gives not only some sense of how busy and vibrant the city was in former times, but also an excuse to come and visit a second time!

A number of [the author]'s points were valid, but it should be borne in mind that the two publications were entirely different in style, and for different audiences and purposes. Like should be compared with like, but we very much appreciate suggestions for improvement. However, it was very disappointing that [the author] felt unable to recommend the Bath Trail – we have had overwhelming support from many different quarters. The team, I believe, are rightly proud of the Bath Trail and they worked very hard and gave up considerable amounts of their free time to see the project through.

Yours sincerely,

Colin Axon
Project Leader
Bath Scientific Heritage Trail
British Association for the Advancement of Science

theBA
communicating science
West of England Branch
www.ba-west.org.uk

Bath Scientific Heritage Trail

Project Leader: Colin Axon
38 Grove Park Avenue, Brislington, Bristol, BS4 4JQ.
Telephone: 0117 908 3078
Email: C.J.Axon@bath.ac.uk

24th May, 2002.

Dear Lucy,

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British Association for the Advancement of Science
23 Savile Row, London W1X 2NB. Telephone 0171-973 3500 Fax 0171-973 3051
Chief Executive Dr Peter Briggs
VAT No 242 4041 07 Registered Charity No 212479

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The Oxford Science Walk & Talk

Led by Olivia Davies

A guided walk took place on Saturday 9th March, 2002, round some History of Physics sites in Oxford. We set off from the Radcliffe Camera:

The walk took in Robert Boyle and Robert Hooke’s plaque, …

… Edmond Halley's former residence, …

the Museum of the History of Science, …

… the Sheldonian Theatre and Wadham College, and finished with a lecture given by Professor Robert Fox, entitled "Science in Oxford", in the Lindermann Lecture Theatre at the Clarendon.

Beauty in Physics – the life and work of Paul Dirac

Professor Norman McCubbin
Rutherford Appleton Laboratory

Last year, 2002, was the centenary of the birth of Paul Dirac who was, unquestionably, one of the greatest physicists of the 20th century. As part of the centenary celebrations, the IoP, through its High Energy Particle Physics and History of Physics Groups, organised a half-day meeting held during the IoP Congress in Brighton in April. A capacity (actually over-flowing) audience heard a programme of talks from distinguished speakers.

Dirac is best known for his prediction of anti-matter in 1930. The discovery of the anti-electron (or positron) in 1932 led to the award of the 1933 Nobel prize which he shared with Schroedinger. Characteristically, Dirac wanted to refuse the prize because of the publicity it would bring, but he was persuaded that refusal would attract even more! The Nobel prize was the culmination of an astonishing few years in which Dirac clarified the structure of quantum mechanics, laid the foundation of quantum field theory, discovered the relativistic equation of the electron (the Dirac equation, which explained in a natural way the electron's spin and magnetic moment and led to the prediction of anti-matter) and found time to write his classic textbook, *The Principles of Quantum Mechanics*, which has never been out of print since it was first published in 1930. He held the Lucasian professorship at Cambridge from 1932 until his retirement in 1969. He was then emeritus professor at Florida State University until his death in 1984.

The Purest Soul: Dirac's Style and Philosophy of Physics

Professor Helge Kragh
University of Aarhus

In the opening talk, Professor Kragh, author of *Dirac: a Scientific Biography,* gave an insightful account of Dirac's work, interspersed with episodes from his life. Professor Kragh described Dirac's highly distinctive style of thinking. Although uninterested in philosophy, he developed, almost unconsciously, a philosophy of science which he later rationalised into what he called "the principle of mathematical beauty". His discovery of the Dirac equation was a spectacular success of this approach, but it also caused him to reject the whole renormalisation programme of modern quantum field theory.

Dirac's Influence on Physics and Mathematics

Professor Sir Roger Penrose
University of Oxford

Professor Penrose gave a sparkling survey of Dirac's many contributions. (He recalled hearing Dirac lecture on Quantum Mechanics, but regretted that a moment's inattention had caused him to miss one of Dirac's key insights!) Professor Penrose noted the beguiling effectiveness of Dirac's *bra* and *ket* notation, and the fascination of the "double-rotation" property of electron spin. Professor Penrose emphasised that some of Dirac's work had had far-reaching consequences in main-stream mathematics: the Dirac equation had triggered major developments in the theory of differential equations, and Dirac's insights not only provided the delta-function, so useful in mathematical physics, but inspired the profound mathematical theories of distributions and hyperfunctions, developed later by others.

Dirac, Anti-Matter and the Universe

Professor Neil Turok
University of Cambridge

Professor Turok gave a fascinating account of the matter-antimatter asymmetry, one of the most intriguing (and locally important!) aspects of the universe. The whole subject originates with Dirac's intepretation of the negative-energy solutions of his equation, leading to his stunning prediction of anti-matter, but the asymmetry goes beyond the Dirac equation. Professor Turok surveyed some of the theoretical ideas, emphasising that a full understanding will require substantial further input from experiment.

Progress in Particle Physics?

Sir Christopher Llewellyn Smith
University of Oxford

Sir Christopher Llewellyn Smith brought the meeting to a close with an authoritative review of the present state of particle physics. Sir Christopher noted that quantum field theory, originated by Dirac in 1927, is now the undisputed language of particle physics. Over the last decade precision data from the LEP electron-positron collider at CERN has tested and confirmed the Standard Model of particle physics to a remarkable degree, allowing, for example, the mass of the top quark to be inferred from the "loop corrections" of the theory. However, as Sir Christopher stressed, quantum field theory also predicts the need for substantial extensions to the Standard Model before it can be considered a satisfactory picture.

Airy

Airy: the Northumbrian Astronomer†

Dr. Ben Rudden (Text)
Savvas Papagiannidis (Photos)

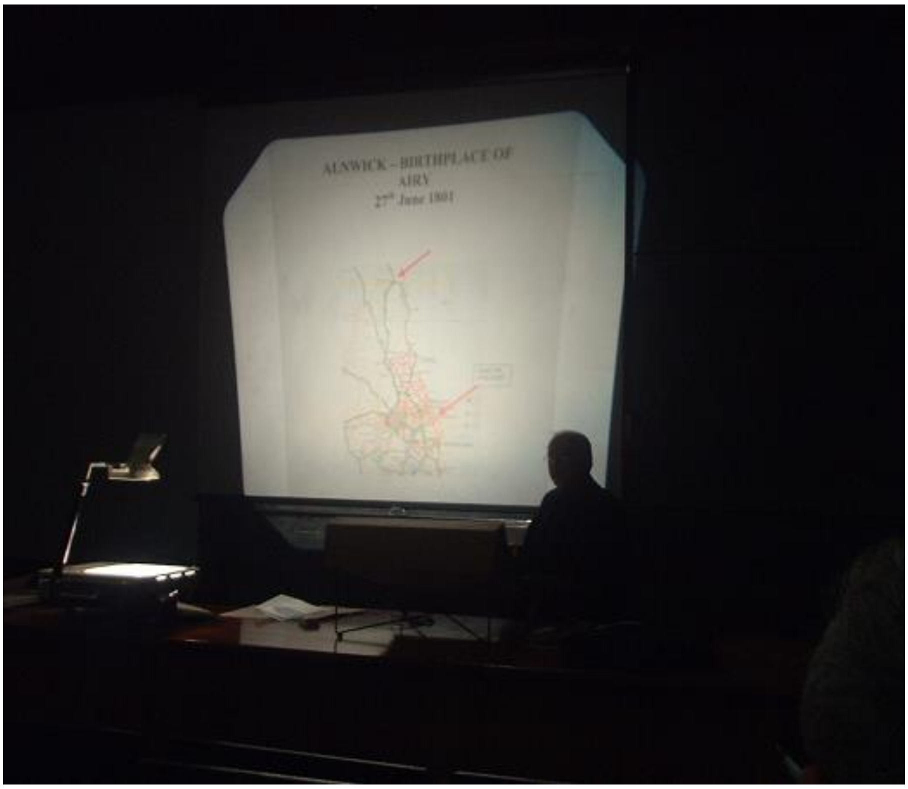
On October 19th at Newcastle University, the North Eastern Branch hosted the History of Physics Group Autumn Meeting, at which the topic was the life and work of Sir George Biddle Airy. This was very appropriate since Airy was born in Alnwick in 1801 and performed perhaps his most famous public experiment to measure the variation in the gravitational force with distance below the Earth's surface at Harton Colliery in South Shields.

Before the main business of the meeting, chaired by Dr. Colin Hempstead, Dr. Ben Rudden, Branch Vice-Chair, presented a brief report about the proposal to unveil an Institute Blue Plaque to Airy in Alnwick. The site of his home in Clayport Bank had almost been confirmed, and it was hoped that the necessary procedures to gain permission to erect the plaque would soon be initiated.

The opening paper: "G. B. Airy's Mathematical Tracts (1826) and its French Backgrounds" was presented by Ivor Grattan-Guiness of Middlesex University.

Airy's flair for mathematics had been evident from an early age, and it is not surprising that he became Senior Wrangler in 1824 with the highest ever marks - double those of the next nearest student. Appointed Fellow of Trinity College, he became Lucasian Professor of Mathematics in 1826 and in the same year published *The Algebraic and Numerical Theory of Errors of Observations and the Combinations of Observations* which, although considered to be unreadable by many, nevertheless became a standard text at Cambridge.

† This account first appeared in the Newsletter of the IoP North-East Branch



Already tremendously influenced by French mathematicians, such as Laplace, Fresnel, Biot and Poisson, in subsequent years he applied this “new” mathematics to virtually all the then known aspects of physics and published a series of *Mathematical Tracts*. Topics included Physical Astronomy, the Figure of the Earth, Earth Precession and Nutation, The Calculus of Variations and The Wave Theory of Optics (undulations), which anticipated “corpuscular” optics using a model of “oscillating bullets”. In 1868, with minor revisions, a fifth tract appeared, which was essentially a book in its own right.

From a mathematical standpoint, Airy was no innovator but his contributions had perhaps been underestimated. As the speaker commented, “there were few peaks but just a huge mountain range of achievement”. Indeed, his tracts provided a model for future Physics and Mathematics texts and established our classical division of physics into Mechanics, Optics, Sound, etc.

The second presentation "Equipping the Royal Observatory" was given by Robert Warren, Assistant Curator of Navigation at the Maritime Museum.

In 1835, Airy went to Greenwich and after the death of John Pond, who had been director since 1765, took over and was appointed as the seventh Astronomer Royal. He found that there had been no systematic analysis of planetary and lunar observations, and he immediately set about reducing all the data from 1750 to 1830. Moreover, realising that the demands of naval chronometry were impeding the development of positional astronomy he at once started to re-equip, install and design instruments which would significantly improve the accuracy of astronomical observations. With a single-minded and somewhat ruthless dedication he transformed the observatory, and paved the way for innovations, which continued into the next century. He sought out the best craftsmen to make the instruments he had designed so that the process of recording and analysing data could be simplified and the results published as quickly as possible. He openly said that any idiot could observe after a few days practice, and certainly regarded "observers" as the lowest form of life in the Observatory. But it was the observational precision which was important, and by devising ingenious automatic systems, using fewer components and establishing rigorous measurement routines, human error was reduced and accuracy increased.

Under Airy, the Observatory changed from a supplier of data to the Royal Navy to a major research institution. With the addition of the Altazimuth telescope in 1847 and the Airy Transit Circle in 1850, a huge advance on existing technology was achieved, and it epitomises the revolution in working practice that he had introduced at the Royal Observatory. International acclaim followed in 1884 when Airy's Meridian was recognised as the international longitude zero.

In the final presentation, "The Man and the Astronomer Royal", Allan Chapman of Oxford University placed Airy's work within the context of the man himself and his early influences.

George Airy's father, William, and his mother, Ann Biddell, both came from Suffolk farming families, but his work as a Tax Inspector had taken William to Alnwick where George was born in 1801. When they returned to Hereford he attended Byatt Walker's school in Colchester and at the age of ten he left in top position. He had acquired useful skills at school but also had benefited from the private study of his father's books. From 1812 Airy had spent his summers with his mother's brother, Arthur Biddell, who had a farm near Ipswich. In 1813 when his father was dismissed for embezzlement, he was taken in by his uncle and in an attempt to distance himself from the disgrace, adopted the name "Biddell", but did revert to "Airy" later on.

These were important years, because his uncle was an educated man with an excellent library containing books on chemistry, optics and mechanics which Airy avidly studied. In addition Biddell numbered many leading scientists amongst his friends and their influence on the young Airy was marked and was a major factor in his decision to pursue an academic career. Although he attended Colchester Grammar School from 1814 to 1819, he virtually taught himself and excelled in English, Latin and Greek as well as in mathematics and was famously noted for having a good memory. He also developed a wide range of interests and fascinations from brewing vats and clocks to steam engines and pumps.

His family problems had rendered him poverty stricken, so when he won a scholarship for Trinity College, Cambridge, he found himself a poor boy among rich men and had to work as a servant to make up his fees. In fact, had it not been for his uncle's financial help he could never have afforded to go to university.

After graduation, he followed the career as outlined above by the first two speakers. Personally, however, he was much more interested in marrying a vicar's daughter, Ricarda Smith, whom he had met on a walking tour of Derbyshire in 1824, but as he had insufficient income to support a wife, her father had refused permission. This made Airy determined to obtain a position with a salary commensurate with marriage, but he had to wait another six years until his annual earnings at the Observatory increased to £500.

Family life suited him, and his wife and children adored him. His scientific interests always came a poor second to his home, and visitors said how informal a household it was. Nothing pleased him more than to accompany himself on the piano whilst singing some of his extensive repertoire of Suffolk folk-songs and drinking a glass of his favourite beer. All this was in stark contrast to the somewhat strict regime he imposed at the Observatory, where his relationships with colleagues were not always pleasant and often somewhat vindictive. He had a well-known long-running enmity with Charles Babbage and had described his "Calculating Machine" as worthless, and there was also his apparent failure to detect Neptune based on the calculations of the astronomer John Adams, and the subsequent "who did or did not do what" dispute.

He held the post of Astronomer Royal until 1881, when he resigned and lived the rest of his life with his two unmarried daughters in the White House close to Greenwich Park, where he died in 1892.

The three excellent and informative presentations painted a very clear picture of Airy the man and Airy the scientist and of the significant contribution he had made in a period of enormous changes in science, technology and society in nineteen century Britain.

The meeting was followed by the Group Annual General Meeting, chaired by Professor Ian Butterworth.

Airy's *Mathematical Tracts* (1826, 1831)

Professor Ivor Grattan-Guiness
Middlesex University

Airy's Cambridge career was pretty meteoric: Senior Wrangler in 1823, a fellowship at his college (Trinity) in the following year, and Professor of Mathematics in 1826 until switching to the Astronomy chair in 1828. He held this post until becoming Astronomer Royal in 1835.

As well as various papers in applied mathematics and astronomy, Airy also produced a book of *Mathematical Tracts* in 1826. It was composed of four texts: three tracts on aspects of celestial mechanics (basic formulations, the shape of the Earth, and precession and nutation), and a short piece on the basic features of the calculus of variations. His purpose was educational: to update the student on topics where he felt the available English teaching literature to be out of date or silent. His book was largely an addendum to the textbooks on mechanics that had been written recently by his friend William Whewell, and to Robert Woodhouse's treatise on astronomy.

Five years later a second edition appeared, more than twice the length of the first. The additions lay almost entirely in a substantial addition to the first tract, mainly on expansions of astronomical variables; and especially a long new tract on *the undulatory theory of optics*, where Airy gave a detailed summary of the recent theory due largely to Jean Fresnel, which was overthrowing the previous ballistic theory developed by P. S. Laplace and some of his followers. This tract seems to have become the main guide in the optics syllabus for the mathematics Tripos; and, together with John Herschel's book-length article published in about 1828, they were the first major accounts in English of the new optics.

Two further editions of the book appeared in 1842 and 1858, and the tract on optics appeared on its own in 1868 and 1877. As usual with Airy, his book was written to fulfil specific aims. Neither a monograph nor a textbook, although (rather high up!) the level of the latter, its influence was somewhat secondary to the writings of Whewell and Herschel mentioned above; but it well served the purposes that its Cambridge professorial author intended.

- Grattan-Guinness, *Convolutions in French mathematics, 1800-1840. From the calculus and mechanics to mathematical analysis and mathematical physics* (1990, Basel: Birkhäuser; Berlin: Deutscher Verlag der Wissenschaften), 3 volumes.
- P. M. Harman (ed.), *Wranglers and physicists* (1985, Manchester: Manchester University Press).

George Biddell Airy: Equipping the Royal Observatory

Dr. Rob Warren
Royal Observatory, Greenwich

When HMS *Beagle* returned from its second surveying voyage in 1836, it was already very well known. When moored at Greenwich it quickly became a popular tourist attraction. In order to minimise disruption on board, one of the crew, Lieutenant Sullivan, had been ordered to direct 'respectable looking persons' to the official entrance and the 'less desirable people' to scale a ladder. Sullivan directed one particularly plain-looking man to the ladder. Minutes later, the Captain was on deck demanding to know why the Astronomer Royal had been treated with such scant ceremony.

That Airy didn't announce who he was says a lot about the way in which he approached his role as Astronomer Royal. He was more interested in the job in hand than flaunting the privileges attached to such a prestigious position. His forthright, down-to-earth attitude was felt at the Royal Observatory from the very beginning of his tenure in 1835 until long after he retired in 1881.

Airy became Astronomer Royal in 1835. In the years before he took over, the Royal Observatory had fallen into disrepute. His predecessor, John Pond, had been an excellent observer but suffered with poor health in later life and was absent from his duties for long periods of time. Without good leadership, the Observatory had declined.

Despite the fact that Airy was not an observer, he revolutionised the way in which the Observatory operated. This can be seen most clearly in two ways. First, under Pond, the processing of the raw observational data had fallen way behind and Airy made it a priority to get the backlog of data reduced, published and into the public sphere as quickly as possible. In addition, he wanted any new data also to be published as quickly as possible. Second, the observing instruments Airy inherited were old and outdated. His other priority was to replace all the major instruments. Most often, they were designed by himself.

> Whatever we do, we ought to do well. Our present instruments were … the best in the world; but they are not so now.
>
> (George Airy, Report to the Board of Visitors 1847)

Airy was pragmatic about the problems he inherited. The decline was due, he said, to Pond's ill-health (Pond died in 1836), the inefficiency of Pond's first assistant (Airy took the job on the understanding that Pond's first assistant was sacked) and the oppression of business due to work on chronometers (Airy felt the demands of the Admiralty had got in the way of the real work of the Observatory).

During 1835, Airy left things as they were. In 1836 he recorded 'my new system began'. One of the first things he did was to enclose the land around the Observatory. He did this partly to unify Observatory site, including the new buildings he had proposed. He also did it to 'deliver him from the inconvenience of the public gaze.'

One of his first jobs was to change the way the raw observational data was processed. He bought into use a set of skeleton forms from which the computing staff could work. The elimination of error from the calculations was his priority and he devised the forms with this in mind. They took the computers through every step of their calculations, stripping down complex and difficult processes into small, straightforward tasks. This production line method allowed them to work quickly and efficiently. If errors were not eliminated altogether by this process, they were at least minimised and traceable. Another advantage was that relatively inexperienced people could carry out the work, allowing new staff to begin working quickly.

Airy's other main concern was the out-of-date instruments at the Observatory. His aim was to upgrade and update all the principle observing instruments but once again, he changed the way in which this process happened. In the past the Royal Observatory had relied to a very large extent on the individual instrument maker. Abraham Sharp, George Graham and John Bird all made instruments for the Royal Observatory and were commissioned by the Astronomer Royal to design and supply specific instruments. This method placed the maker at the heart of the process. By contrast, Airy placed himself at the heart. Having identified a particular observational need, he designed an instrument that was capable of meeting that need easily and effectively. He would then approach the engineers, clockmakers, carpenters and opticians most capable of producing the individual parts. By taking this central role in the process, he ensured that when he brought each component of a new instrument together they would be of the highest possible standard.

Airy treated observations, and to a large extent the observers themselves, as simply one step in the more important process of making the data widely available. In a letter to the Admiralty, Airy said ‘the lowest of the employment in an observatory is the mere observation. No intellect and very little skill are required for it. Any idiot, with a few days practice, may observe very well.’

Airy gives the impression that if he could have done away with observers altogether he would have. And in a sense that was exactly what he did, at least as far as was practically possible. By designing well-engineered, easy-to-use instruments, the actual input of the observer was increasingly passive. In the same way the role of the computer had become diluted by Airy’s production line philosophy, so had the observer’s.

To illustrate Airy’s approach to running the Royal Observatory, I want to look at four of the instruments he designed and commissioned. His first major addition was the Altitude & Azimuth Instrument, or ‘Altaz’, which came into operation in 1847. Plotting the position of the Moon had been a part of the Royal Observatory’s work from its earliest days. Up to that point, however, all positional observations of the Moon had been made with meridian instruments. Since these were fixed on a North-South axis, some parts of the Moon’s orbit still remained unobserved. The addition of the Altaz would allow those missing areas to be covered.

It was built by Ransome & May of Ipswich, best known for their manufacture of agricultural machinery, and its optics were by Troughton & Simms. Both companies were to be regularly used by Airy over the years. The instrument was ordered in 1843 and was mounted in the New South Dome, adjacent to Flamsteed’s original observing room, in 1845. It was supported by a 26-foot pier that was unconnected to the floor of the dome. This would enable the observations to remain unaffected by any local disturbance or vibration. It weighed about 1 ton and stood 3-stories high. It was used for measuring the position of the Moon until 1897 and remained in position until 1910.

Airy added two major instruments in 1851. The first was the Reflex Zenith Tube made by William Simms. Accounting for atmospheric refraction in positional astronomy is a difficult problem to overcome. Refraction will cause an object to appear in a slightly different position to its actual position. In addition, the lower the object is in the atmosphere the greater the effect refraction has. Refraction also varies according to other factors such as pressure or temperature.

As a consequence, if very precise observations are needed then directly overhead is the best place since refraction is least effective at the zenith. This fact was well known even in the earliest days of the Observatory. The first Astronomer Royal, John Flamsteed, made a series of zenith observations.

In May 1848, Airy began to develop plans for a Reflex Zenith Tube. His idea was to use mercury, or quicksilver, as a mirror. Working in a similar way to a reflecting telescope, the image of the star was reflected from the surface of the mercury back up into the eye-piece. Airy described the principle of the instrument:

> Let a basin of quicksilver be placed below the object glass, but no mechanical connection with it….Such an instrument would at least be free from all uncertainties: and might be expected, as the result of this extreme simplicity, to give accurate results.
>
> (Autobiography p194)

Despite Airy’s attention to detail and his quest for simplicity, the mercury suffered from vibrations. As a result the surface of the liquid was disturbed and accurate observations were impossible. He tried to solve the problem by isolating the mercury tray on a pier set into the ground. When the problem persisted he had the instrument moved to another part of the transit room.

The object glass of the Zenith Reflex Tube had been made by Dollond in 1793. It was the largest lens he ever made and had previously been used in the 10-foot Troughton telescope. This shows another of Airy’s traits, that of saving money. Whenever he could, Airy would find ways of keeping down costs and if he could reuse components he would. This thrifty approach allowed him to both minimise the amount of money he asked the Admiralty to provide and increase his chances of actually getting it. The Reflex Zenith Tube was mounted in 1851 and remained in use until 1923.

The second instrument he added in 1851 has become the most important and well-known instrument in the history of the Royal Observatory, the Airy Transit Circle. It was built by Ransomes & May of Ipswich, with Troughton & Simms providing an object glass of 8.1 inches.

Improvements in telescope design had meant discoveries were being made that the Observatory had no way of verifying. One such discovery was by the Italian astronomer and mathematician Giuseppi Piazzi in 1801. He found a minor planet (later named ‘asteroid’ by William Herschel) in the region between Mars and Jupiter. By 1845, when Airy first proposed the new instrument, more were being discovered and the current transit instrument, the Troughton 5-inch, had no way of detecting them. The introduction of the optically superior Airy Transit Circle enabled their position to be measured.

The Transit Circle, like his other instruments, was designed to be both simple to use and, as far as possible, error free. Throughout its working life, the instrument was updated and improved. One innovation was its ability to simultaneously record an object’s altitude and time of transit. This not only greatly simplified the process of making transit measurements, but it also allowed an individual’s reaction time to be removed from the data, thus further reducing any error. It remained in continual use until 1938 and the last observations with it were in October 1954. In total, the Airy Transit Circle made over 600,000 observations.

The final instrument I want to look at is the 12¾-inch Merz Refractor, again built by Ransome & Sims of Ipswich. The object glass was made by Merz of Munich with the optical finishing completed by Troughton & Simms. This was an equatorially mounted instrument and was driven by a water clock.

Although it was Airy’s choice to add this instrument, he was initially reluctant to move the work of the Royal Observatory into realms outside that of the original Warrant. He justified his feelings in his annual report:

> Little attention has been given to the Equatorials, as I consider the branch of astronomy to which they apply to be so well followed up in other observatories … that in general it is impolitic for us to devote much time to it.
>
> (Report to the Board of Visitors in 1849)

Despite his reluctance, a new telescope was commissioned with an object glass of 12¾ inches, about twice the size of the biggest equatorial at the Observatory. It was commonly known as the 'Great Equatorial' and was very similar to the 'Northumberland' in Cambridge, a telescope designed by Airy prior to his appointment as Astronomer Royal. It was housed in the new 'South Eastern Dome', a purpose-built dome to the East of the transit room. It came into use in 1859 and for about 30 years it was used in a variety of ways including the observation of planets. Although it was replaced in the dome by the much larger 28" refractor in 1893, it continued its life as a guide-telescope for the 26-inch photographic refractor in the dome of the New Physical Laboratory.

It has been a criticism of Airy that he was not an active observer and that, as Astronomer Royal, he should have been. It is true that he made very few observations in his 46 years in charge, but to emphasise this point is missing a more important one. That is, under his tight and skilful leadership, the Royal Observatory flourished as never before. In addition, the instruments he designed led the world in optical and engineering quality. By establishing a very different role to that of his predecessors, perhaps more akin to a director, the Royal Observatory led the world in positional astronomy. He put in place a very effective infrastructure that led to its published data being used in about 75% of all navigation charts. Because of this, the Observatory was established as the home of the Prime Meridian of the World in 1884.

Not only did Airy revolutionise the working practices and the quality of output of the Observatory, his leadership was so influential that the Observatory was literally never the same again. Undoubtedly Airy was just what was needed in 1835, bringing great authority and stability and establishing a working method that remained at its heart for many years after his death in 1892.

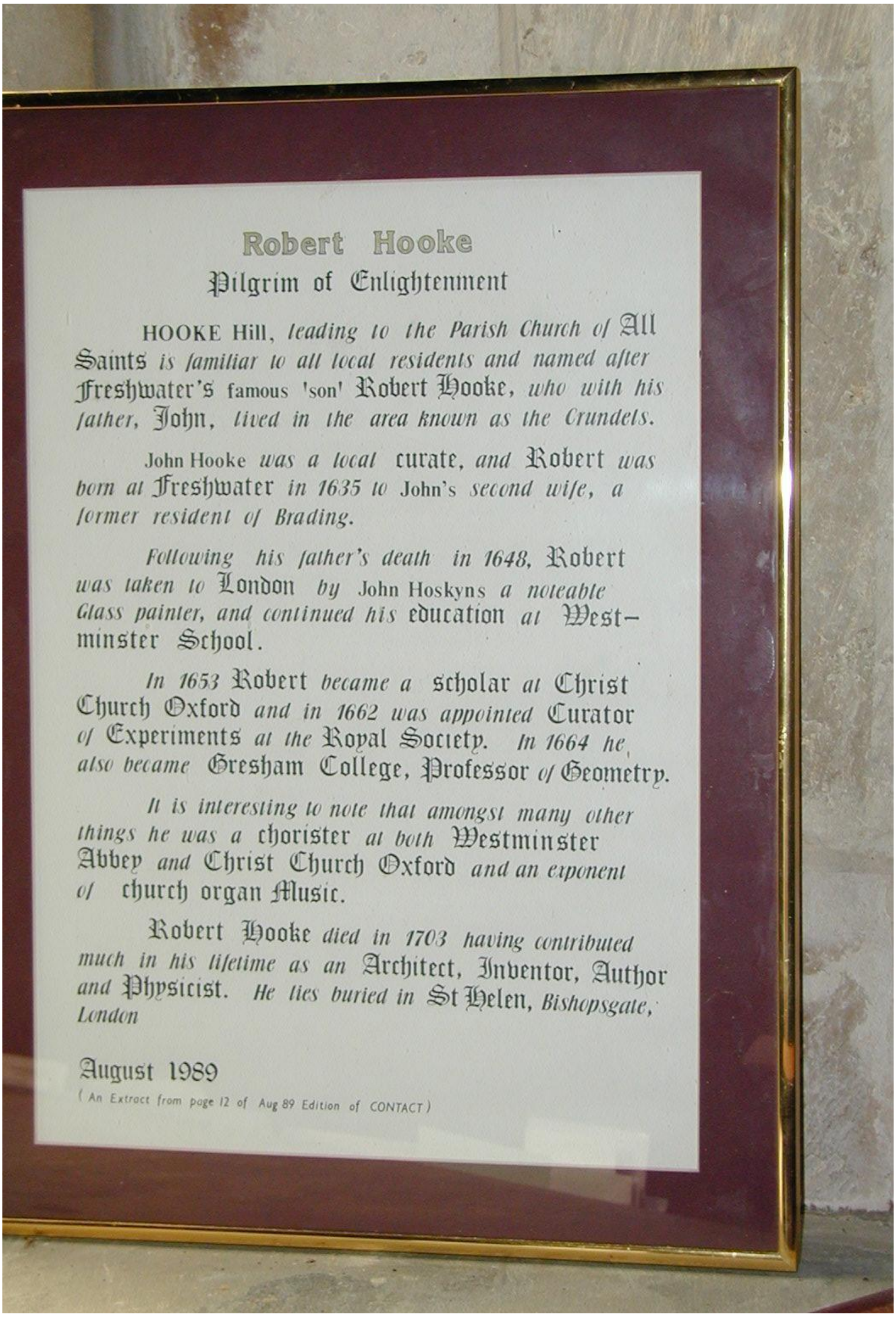
A Hooke Miscellany

To mark the tercentenary of Hooke's death, we have a collection of news items from Kate Crennell:

Hooke on the Isle of Wight

While on holiday recently in the Isle of Wight I happened to walk through the village of Freshwater, and visited the church of All Saints.

Inside to my surprise I found a framed document …



Robert Hooke
Pilgrim of Enlightenment

HOOKE Hill, *leading to the Parish Church of* All Saints *is familiar to all local residents and named after* Freshwater's famous 'son' Robert Hooke, *who with his father,* John, *lived in the area known as the Crundels.*

John Hooke *was a local* curate, *and* Robert *was born at* Freshwater *in 1635 to* John's *second wife, a former resident of Brading.*

Following his father's death in 1648, Robert *was taken to* London *by* John Hoskyns *a noteable Glass painter, and continued his* education *at* Westminster School.

In 1653 Robert *became a* scholar *at* Christ Church Oxford *and in 1662 was appointed* Curator *of* Experiments *at the* Royal Society. *In 1664 he also became* Gresham College, Professor *of* Geometry.

It is interesting to note that amongst many other things he was a chorister *at both* Westminster Abbey *and* Christ Church Oxford *and an exponent of* church organ Music.

Robert Hooke *died in 1703 having contributed much in his lifetime as an* Architect, Inventor, Author *and* Physicist. *He lies buried in* St Helen, *Bishopsgate, London*

August 1989
(An Extract from page 12 of Aug 89 Edition of CONTACT)

… recording that Robert Hooke had been born there when his father was a curate. His mother is buried in the churchyard.

The document reads:

Robert Hooke
Pilgrim of Enlightenment

HOOKE HILL, leading to the Parish Church of All Saints is familiar to all local residents and named after Freshwater's famous "son" Robert Hooke, who with his father, John, lived in the area known as the Crundels.

John Hooke was a local curate, and Robert was born at Freshwater in 1635 to John's second wife, a former resident of Brading.

Following his father's death in 1648, Robert was taken to London by John Hoskyns a noteable glass painter, and continued his education at Westminster School.

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Robert Hooke died in 1703 having contributed much in his lifetime as an Architect, Inventor, Author and Physicist. He lies buried in St. Helen, Bishopsgate, London.

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(*Does anyone know this newsletter 'CONTACT'?)*

Oxford Exhibition

From 3 January 2003 the Museum of the History of Science, Broad Street, Oxford (tel 01865 277 280, website http://www.mhs.ox.ac.uk) has an exhibition, "***Ingenuity in Restoration England: Hooke, Morland, Papin and Wren".***

Hook international conference

An international conference to honour Hooke's memory is also being held in London, at the Royal Society, under the auspices of Gresham College, from 7-9th July 2003. Particulars can be obtained from Mrs Julie Jones (01235 762 744, julie.jones@btinternet.com).

The Road to Stockholm: Nobel Prizes, Science and Scientists
by *István Hargittai*

Book Review by Kate Crennell

Publisher: Oxford University Press 28 March 2002 UK price £19.99 (hardback)
ISBN 0-19-850912-X 360 pages 24pp halftone plates

The year 2001 was the centennial of the first award of the Nobel prizes. They remain the only science prizes widely recognized by the general public and the media; for a few days each Autumn there is international and local news, sports news and ***science news*** when the achievements of the year's Nobel Laureates are acclaimed. There are many other science prizes, how has this one captured the public attention? Have you ever wondered how the selection process works? Or whether the award of this prize changes the lives of those who receive it? István Hargittai has thought about this for some years; he has interviewed some 70 Nobel Laureates and other distinguished scientists in the fields of "chemistry", "physics", and "physiology and medicine" and distilled his findings into this book, where he explores the answers to these questions. This book is not concerned with the Prizes in economics and literature, and the author has also sensibly refrained from trying to describe the science itself in detail: that would have made a much longer book. If you want to learn more of the science there are copious references in the Notes section which is almost 50 pages long, and useful for History of Physics Group members who are curious about other topics.

The first chapter explains the history of the Nobel Prizes and the annual selection process and mentions other science prizes, including the "reverse Nobel prize" known as the "*Ig Nobel prize*" bestowed by the *Annals of Improbable Research* on individuals whose "achievements cannot or should not be reproduced".

The next chapter **"Nobel Prizes and National Politics"** explores the distribution of prizes amongst scientists of various nationalities. One problem is that the scientists themselves are more often citizens of the world than of any one country, and may not themselves have the aspirations attributed to them by others. We read (p. 29) that Boris Vashtein, evaluating the life and work of Dorothy Hodgkin, noted that she "*has done much for the glory of her homeland".* As Hargittai remarks, "*This reflected more Vashtein's way of thinking than Hodgkin's aspirations".* Scientists naturally migrate to other countries even in peace time, and in the 1930s many who later became Nobel Laureates fled Nazi Germany. The small number of prizes for Japanese scientists may also be an indication of the timidity of Western Science towards Japan.

"Who wins Nobel prizes?" is the question posed in the third chapter**.** The author tries to assess the common qualities which Nobel laureates possess, and speculates on whether it may be possible to train people to become Prize winners. A later chapter on **"Mentors"** describes how students naturally wish to work with inspiring eminent scientists who may later win Nobel prizes; a famous example is Enrico Fermi who came to Rome in 1927 looking for students, and found Emilio Segrè, then enrolled as an engineering student, and offered to teach him physics. After graduation Segrè worked with Pieter Zeeman in Holland and Otto Stern in Hamburg before returning to Rome where he participated in the discovery of slow neutrons in Fermi's laboratory. Both Segrè and Fermi emigrated to America just before the second World War where both of them were mentors for younger scientists.

Equally interesting is the last chapter, **"Who did not win?"**, where possible reasons are discussed as to why those who surely deserved a Nobel prize did not receive one. J. D. Bernal is perhaps the most notable crystallographer: he did the first X-ray diffraction experiments on a protein in 1934 and thus opened up the whole science of protein crystallography, the study of the structure of viruses and other macromolecular structures. Another example is Leo Szilard, nominated by Maurice Goldhaber for the prize in Physics in 1949 when he stated "His contributions are not confined to Physics and Chemistry. His interest in his fellow man and in the preservation of peace has always been intense." James Watson, joint winner of the prize for medicine with Francis Crick in 1962, for the discovery of the structure of DNA, was a great admirer of Szilard. He said, "He was always two steps ahead of everyone else. When you go too fast it threatens people." Both Bernal and Slizard might be termed "scientific visionaries", and although they may not have published as much as others, their ideas were a great inspiration for others who did win the Prize. Since the deliberations of the Nobel

Prize Committees remain sealed for 50 years we cannot know exactly why Bernal and Slizard did not receive prizes. There are also some important newly discovered topics such as "quasi-crystals" whose discoverers have not yet received a Nobel Prize. Dan Shectmann received the Aminoff Prize for his discovery of quasi-crystals in 2000. Hargittai speculates that the Aminoff Prize may be becoming a “consolation prize” for those not awarded a Nobel prize.

The book lists the Nobel Prizes awarded in scientific fields up to 2001; it has an index to the names of the scientists but *no subject index*. This would have made it a much better reference tool for those who wonder which important scientific discoveries have been awarded a Nobel prize. Nevertheless, the book is very good value for money, a well produced hardback for just under £20. The publisher saved money by binding all the photographs together in one place, but I would have preferred them distributed throughout the text. If you are interested in the history and sociology of science, or just wondering how to groom your students to become future Nobel prizewinners, buy this book.

Relevant Web Addresses

1. The Oxford University Press site is **http://www.oup.co.uk/** search their books catalogue for the ISBN or author to find the publisher’s press release. You can buy the book at full list price through this site, but you may find other Internet book sellers with discount prices.

2. A site devoted to this book is **http://www.roadtostockholm.com/** it has extra information, including reviews, photographs not featured in the book itself and information about the author. This site is not always obtainable, and alternate URL is: **http://www.princeton.edu/~eszter/rs/**

3. The ***Electronic Nobel Museum*** is at **http://www.nobel.se** which has full details of all the Nobel Laureates, with portraits and bibliographies. Philatelists can also access the catalogue of Swedish postage stamps now issued annually to commemmorate the Nobel Prize winners.

4. The **Nobel Prize Internet Archive** at **http://www.nobelprizes.com** has more indexes, including the "Nobel Laureates Alma Mater", an alphabetic index of all the Nobel Laureates and a "Nobel Trivia Quiz" which could be useful for those arranging a scientific social "Quiz Night".

5. The Stanford University Library has a set of useful links at: **http://www.slac.stanford.edu/library/resources/more.html#Nobel**

An Astrolabe Miscellany

Astrolabe sessions at British Museum

An article has recently appeared in the Times[‡] about Astrolabes, in “The Register” section, headed “Dumbledore’s computer”. Dr Silke Ackermann, a curator in the department of medieval and modern European instruments at the British Museum, has introduced regular handling sessions of a replica of a 16th century astrolabe in Gallery 44 of the British Museum (2 - 4 pm on Tuesdays and Thursdays, staffed by volunteers). Sessions are free, no booking required.

Do you live in, work in or visit London? Would you like to visit one of these sessions and write it up for the Newsletter? Do let me know – contact details at the front of the Newsletter.

Website with early instruments

Also mentioned in this article was a website at: http://www.mhs.ox.ac.uk/epact/ with a digital collection of European scientific instruments from before 1600, including astrolabes, from the British museum, the Museums of the History of Science in Oxford and Floreance, and the Museum of Boerhoave, Leiden.

With thanks again to Kate Crennell for these

[‡] *The Times newspaper, 28th December 2002*